

SIMULIUM (HEMICNETHA) HIEROGLYPHICUM
(DIPTERA: SIMULIIDAE), A NEW BLACK FLY SPECIES
FROM COSTA RICA

B. V. PETERSON, M. VARGAS V., AND J. RAMÍREZ-PÉREZ

(BVP) Systematic Entomology Laboratory, BBII, Agricultural Research Service, USDA, % National Museum of Natural History, NHB-168, Washington, D.C., U.S.A. 20560; (MVV) Centro de Investigación y Diagnóstico en Parasitología, Universidad de Costa Rica, Ciudad Universitaria Rodrigo Facio, Costa Rica; (JRP) Instituto de Biomedicina, P.O. Box 4043, Caracas, Venezuela.

Abstract.—The female, male, pupa and larva of *Simulium (Hemicnetha) hieroglyphicum*, new species, are described and illustrated. This species occurs in the highlands of Costa Rica, and is most readily differentiated from all other described species of the subgenus *Hemicnetha* by the large number of filaments in the respiratory organ (gill) and the peculiar hieroglyphic-like markings on the thorax and frons of the pupa. A key to the species of *Hemicnetha* known in the pupal stage is provided.

The subgenus *Hemicnetha* Enderlein presently includes about 22 New World species, mostly from the Neotropical Region. The number of species reported by country is as follows: Mexico, 12; Guatemala, seven; Belize, one; El Salvador, one; Costa Rica, two including the new species described here; Panama, six; Colombia, three; Venezuela, six; Trinidad and Tobago, one; Guyana, one; Brazil, two; Bolivia, one; and Argentina with two species (Pinto 1932, Vargas and Díaz Nájera 1951, 1957, Dalmat 1955, Vulcano 1967, Barreto 1969, Field 1969, Ramírez-Pérez 1971, Ramírez-Pérez and Vulcano 1973, Bueno et al. 1979). Two of the species included in the above listing, viz *S. solaris* Stone and *S. virgatum* Coquillett, are known also from the Nearctic Region (Stone 1948). Despite the number of species assigned to this subgenus, there is no comprehensive study of the group. Even so, pupae are known for most of the described species, all of which differ from the distinctive pupa of the new species de-

scribed below. This new species is described to provide a name to use in work currently being done on the black fly fauna of Costa Rica. This is the second paper in a series describing new species from Costa Rica; for the first paper see Ramírez-Pérez, Peterson, and Vargas (1988). A key to the pupae of the described species of *Hemicnetha*, with distributions and references to published figures, is provided.

Simulium (Hemicnetha) hieroglyphicum,
NEW SPECIES
Figs. 1-21

Female (preserved in alcohol).—General body color blackish brown. Length: body, 4.0 mm; wing, 4.08-4.5 mm.

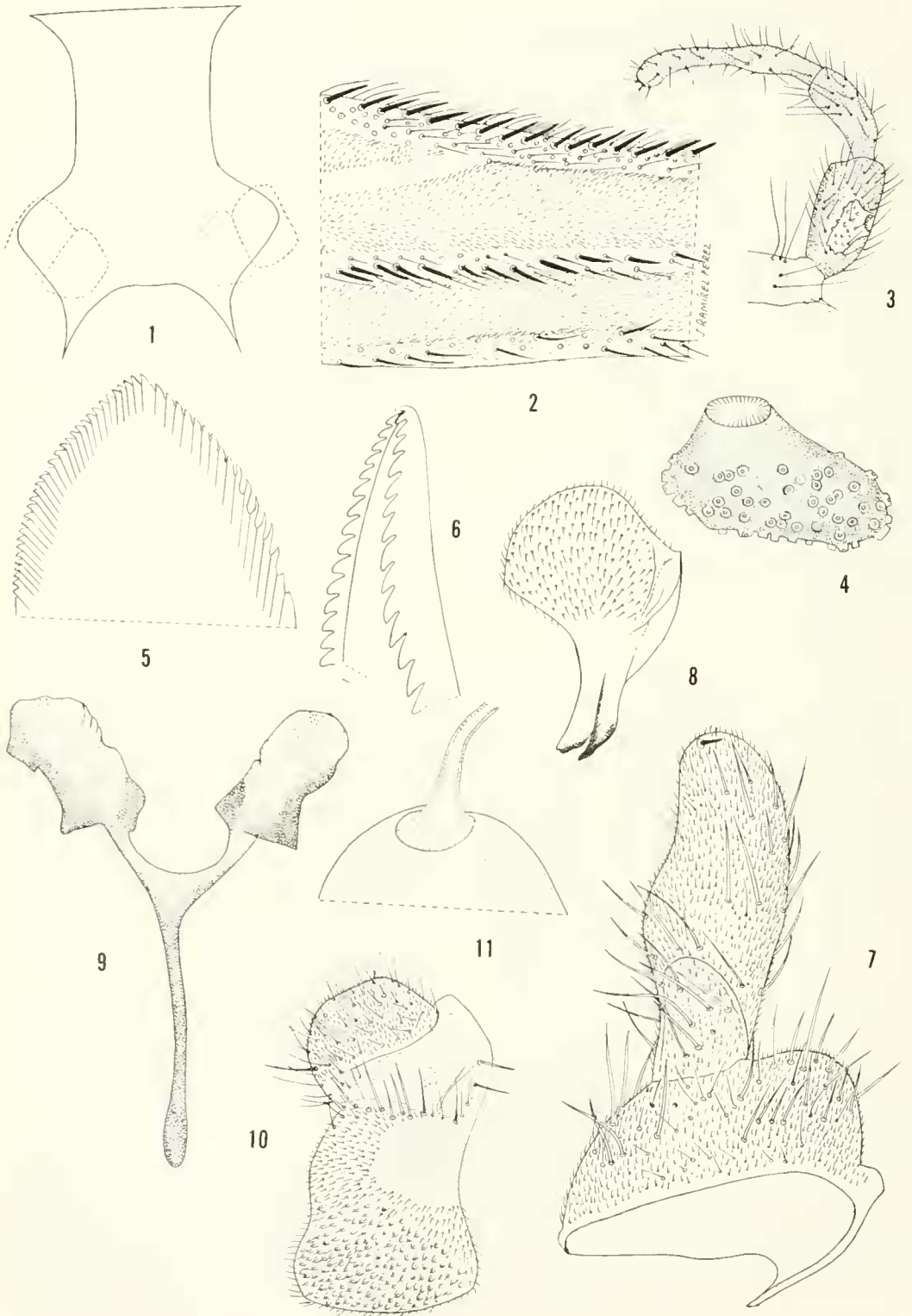
Head: Lightly silvery pollinose. Frons (Fig. 1) moderately broad, at vertex about $\frac{1}{4}$ wider than at narrowest point, distinctly less than $\frac{1}{2}$ as wide as head, and narrower than long; covered with long, decumbent, black pile. Clypeus concolorous or slightly lighter than frons; slightly longer than wide;

covered with long, ventromedially directed, black pile. Occiput silvery pollinose, densely covered with long, black pile; postocular setae black, closely bending over eye margin. Antenna entirely dark brown to black, with nine flagellomeres; pedicel slightly longer than first flagellomere; fine pubescence black. Mandible (Fig. 5) with 44–51 serrations. Blade of maxilla (Fig. 6) with 23–28 retrorse teeth. Palpus (Fig. 3) with basal two palpomeres and fifth palpomere slightly lighter than palpomere three; palpomere five slightly more than twice as long as palpomere three; all palpomeres with black setae. Sensory vesicle (Fig. 4) about $\frac{1}{2}$ as long as its segment, proximally situated, neck absent or very short with an enlarged, ovoid mouth. Median proximal space of cibarium shallow, broadly U-shaped, and with about 45 minute setulae with rounded bases in membrane medially; dorsolateral arms short, rather broad, sclerotized, inner surfaces of arms with numerous, minute, sensory setulae.

Thorax: Postpronotum small; slightly paler than scutum especially along adjoining margin; covered with long, recumbent, golden yellow pile interspersed with some semi-erect to erect, black setae. Scutum with lateral margins narrowly more pale brownish and with a silvery pollinose border extending around margins, posterior declivity broadly silvery pollinose; anterolateral corners of scutum without distinct silvery spots, but in posterior view, with three slender, dark vittae that extend anteriorly from posterior declivity, median stripe longest, lateral stripes extending about $\frac{1}{2}$ distance to anterior margin; scutum densely covered with short, recumbent, golden yellow setae grouped in small clusters, pile longer along anterior and lateral margins and still longer posteromedially; anterior margin of scutum with a number of long, dark, erect setae, and posterior declivity with more numerous, longer, dark setae. Scutellum yellowish brown; densely covered with short, appressed, golden yellow setae, and numerous

long, black setae. Postnotum with dense silvery pollinosity. Pleuron brownish black anteriorly, densely silvery pollinose, becoming paler yellowish brown medially and posteriorly, and often mottled with dark areas; anepisternal membrane brownish yellow, often mottled; mesepimeral tuft of long, black setae. Wing (Fig. 2) membrane hyaline but with a definite brownish tinge; veins brown. Base of costa, stem vein, and remaining veins with black pile; Sc with numerous setae ventrally except for about apical $\frac{1}{5}$ which is bare; R_1 with both setae and spinules dorsally; R_{4+5} setose ventrally; stem of wing just basal to MA lightly sclerotized with a conspicuous oval windowlike area present; fringe of anal lobe and calypter with black setae. Knob of halter yellowish white; stem yellowish brown, with pale yellowish setae. Legs with forecoxa, trochanter and femur yellow to brownish yellow especially on distal margins, these segments with short, golden yellow scales plus longer black setae; tibia mostly black with some yellow medially, tarsus black, both tibia and tarsus with black setae mixed with a few yellow setae. Midcoxa, trochanter, basal $\frac{1}{3}$ of femur, basal $\frac{2}{3}$ of tibia, and about basal $\frac{2}{3}$ of basitarsus yellow, remaining portions of midleg black; with mostly black setae. Hind coxa brown; trochanter, basal $\frac{1}{3}$ of femur, about basal $\frac{1}{2}$ of tibia, and basal $\frac{5}{7}$ to $\frac{1}{2}$ of basitarsus yellow, remainder of hindleg black; with mostly black setae; hind basitarsus swollen, about five times as long as broad; calcipala prominent, stout, broadly rounded apically, reaching to middle of pedisulcus or slightly beyond; pedisulcus moderately deep but not conspicuous. Claw evenly curving from base, with a small but conspicuous subbasal tooth.

Abdomen: Brownish black dorsally, becoming paler laterally and ventrally; basal scale (tergite one) with fringe of long, pale yellow pile; tergites blackish brown, with darker hind margins, covered with short, dark setae; tergite 10 small, subrectangular, wider than long. Pleural membrane paler



brownish yellow, with dark setae. Sternites heavily sclerotized; sternites 2–7 subequal in length, sparsely covered with dark setae; posterior margin of sternite eight with long, black setae. Terminalia as in Figs. 9–11. Anal lobe (Fig. 10) broad, subrectangular, anterior margin slightly concave medially, hind margin nearly straight or slightly bilobed, ventral margin nearly straight, not produced beneath cercus, densely setose. Cercus (Fig. 10) rather small, subrectangular, about two times as high as long, hind margin broadly rounded. Hypogynial valves elongate, $\frac{1}{4}$ longer than greatest basal width, not reaching hind margins of cerci; outer margin of each valve rather deeply concave, inner margin broadly rounded, apex rounded, with a curved, longitudinal ridge that runs from near apex to near inner basal margin, inner $\frac{1}{4}$ moderately sclerotized and bare, remaining area densely microsetose. Stem of genital fork (sternite nine) (Fig. 9) long, heavily sclerotized, twice as long as arms; each arm short, expanding into a large, subrectangular plate with outer lateral margin thickened ridgelike and inner proximal corner thickened as a short, rounded process; arms broadly attached to segment nine. Spermatheca (Fig. 11) globular, heavily sclerotized, without a pattern, but with a small circular membranous area at junction with spermathecal duct; inner surface of spermatheca rather evenly covered with numerous, but well separated, minute spicules.

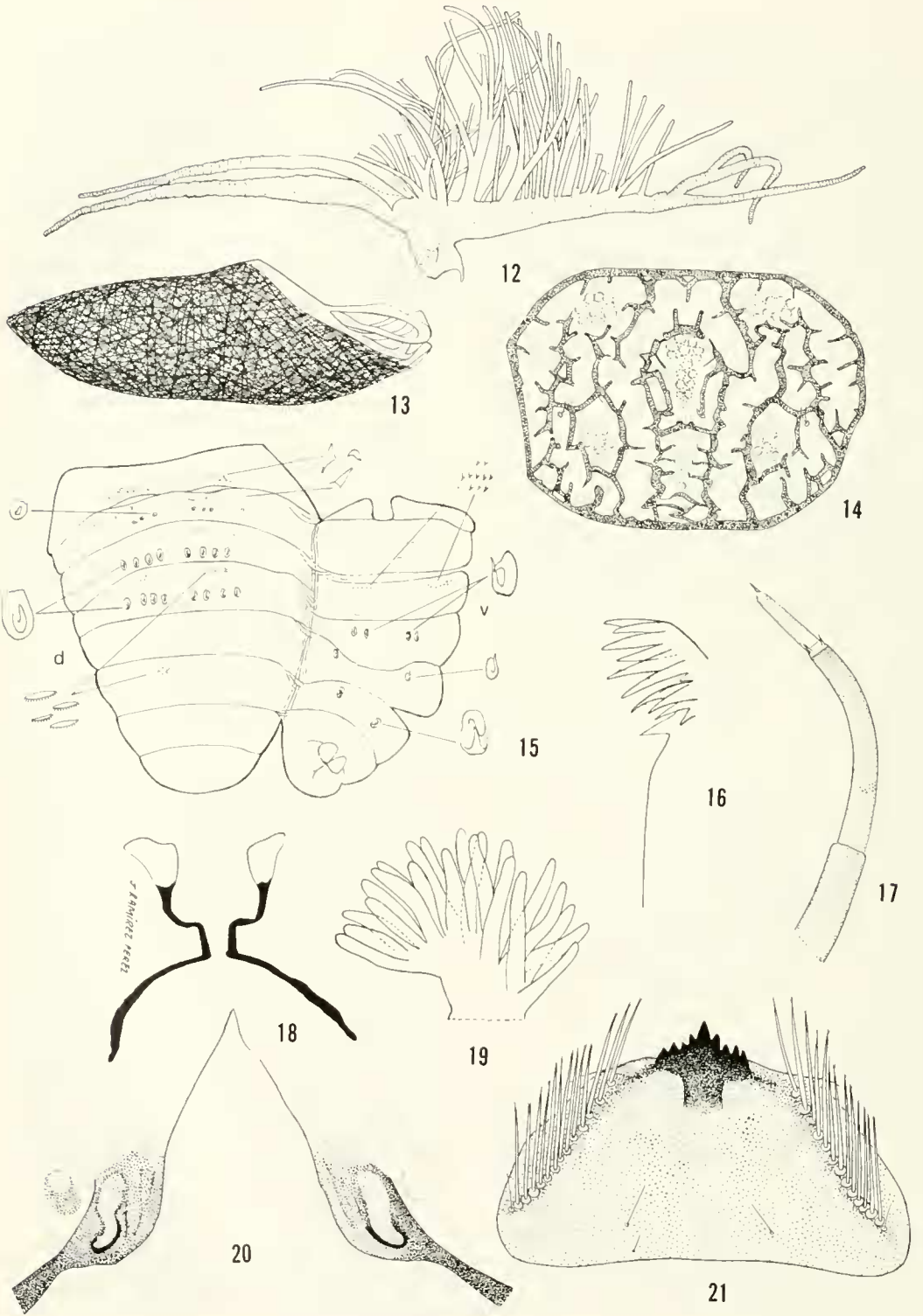
Male. — General body color velvety brown to black. Length: body, 4.6–6.0 mm; wing, 3.9–4.2 mm.

Head: Frons and clypeus densely silvery pollinose, clypeus with erect, black pile. Occiput densely covered with long, black setae. Antenna with scape, pedicel and extreme

base of first flagellomere yellow, rest of flagellum black; first flagellomere nearly twice as long as pedicel; scape with tuft of dark setae that are much longer than sparse setae of pedicel especially those of distal margin, fine pubescence of flagellomeres pale yellow, longer setae black. Palpus entirely dark brown to black, with black pile; palpomere four slightly but distinctly longer than three, palpomere five about three times as long as palpomere three. Sensory vesicle small, about $\frac{1}{3}$ as long as its segment; neck distinct, enlarging to form a round mouth.

Thorax: Postpronotum small, yellow, with short, recumbent, golden yellow pile interspersed with a few more erect black setae. Scutum brownish black, margins, especially laterally and on notopleuron, slightly paler brown, narrowly silvery pollinose along anterior margin but covering most of posterior declivity; densely covered with short, recumbent, golden yellow pile grouped into small clusters, pile slightly longer laterally and posteromedially, posterior declivity with some long, erect, black setae. Scutellum yellow, densely covered with moderately long, semi-erect, golden yellow setae interspersed with some long, erect, black setae. Extreme anterior margin of postnotum concolorous with scutellum, remainder brownish black, densely silvery pollinose. Pleuron dark blackish brown and densely silvery pollinose anteriorly, becoming paler yellowish brown medially and darker brown posteriorly; anepisternal membrane brownish yellow; mesepimeral tuft of long, black setae. Wing membrane hyaline but with a faint yellowish tinge; veins yellowish brown; base of costa, stem vein, and remaining veins with black setae; Sc with about 12 setae at extreme base ventrally; R_1 with both setae and spinules dorsally; R_{4+5} setose ventrally;

← Figs. 1–11. *Simulium (H.) hieroglyphicum*. Figs. 1–6, female. 1, Front view of frons and ocular notches. 2, Portion of wing showing setation. 3, Maxillary palpus. 4, Enlarged view of sensory organ of third palpomere. 5, Tip of mandible showing serrations. 6, Blade of maxilla showing retrorse teeth. Figs. 7–8, male. 7, Gonocoxite and gonostylus (dorsal (inner) surface). 8, Ventral plate of aedeagus, lateral view. Figs. 9–11, female. 9, Genital fork (sternite 9). 10, Anal lobe and cercus. 11, Spermatheca.



stem of wing just basal to MA lightly sclerotized with a conspicuous oval windowlike area present; fringe of anal lobe and calypter brownish yellow, setae often with black bases. Knob of halter white, stem brownish yellow with pale yellow pile. Fore coxa, trochanter and femur yellow tinged with brown, especially on distal margins, tibia and tarsus black; coxa and trochanter anteriorly with yellow setae plus scattered black setae; tip of femur and anterior surface of tibia with appressed, golden yellow scales, rest of setae black. Mid- and hind coxae dark brown; trochanters dark brown mottled with patches of yellow; mid- and hind femora brownish yellow with dark brown apices; tibiae largely dark brown on anterior face but bases and inner surfaces yellow; about basal $\frac{1}{2}$ of first two tarsal segments yellow, their apices dark brown, remaining portions and rest of tarsomeres dark brown; anterior surfaces of mid- and hind femora, tibiae and basitarsi with appressed, golden yellow scales, rest of setae black; hind basitarsus swollen, about three times as long as broad; calcipala prominent, broadly rounded, nearly obscuring pedisulcus; pedisulcus deep. Claw short, slender, with a short but conspicuous sub-basal tooth.

Abdomen: Brownish black dorsally, becoming brownish yellow laterally and ventrally; basal scale with fringe of long, dark setae black at base and distally paler brownish to yellowish; tergites broad, all nearly uniform in width, velvety in texture and with black hind margins, tergites 2–7 each with an oblique, silvery, pollinose patch laterally, covered with short, black setae; tergite 10 small, rectangular, longer than broad. Pleural membrane of segments 3–6 with a dorsal patch of long, black setae just lateral to margin of respective tergites, segment seven with a similar but smaller patch. Ster-

nites 3–8 nearly uniform in width, dark brown on about basal $\frac{2}{3}$, paler yellowish on about distal $\frac{1}{3}$, with black setae. Terminalia as in Figs. 7–8. Gonocoxite (Fig. 7) subrectangular, about $\frac{1}{3}$ wider than long, moderately setose on about distal $\frac{1}{2}$. Gonostylus long, slightly more than three times as long as greatest width at base; margins strongly sinuous, inner margin with distinct bulge at midlength, apical margin rounded, with a single terminal spine. Ventral plate of aedeagus (Fig. 8) with a prominent, broadly rounded ventral lip which, in lateral view, resembles a medieval broadhead ax; in ventral view, body slightly wider than long, lateral and apical margins broadly rounded; basal arms rather slender and straight, obliquely directed outwardly with tips rather strongly curving inwardly. Median sclerite of aedeagus with a slender, straight stem that branches into two broad arms nearly as long as stem, arms tapering distally, narrowly rounded to slightly pointed. Plate of endoparameral organ moderately large, subrectangular, moderately sclerotized; arm only slightly longer than basal plate, twisting, with a series of corrugations and rather poorly defined teeth on outer margin, apical five or six teeth short, stout and better defined than more proximal teeth; aedeagal membrane densely covered with minute spinules arranged in rather regular comblike series of about three to 12 spinules per comb.

Pupa.—Length 6.3–7.0 mm. Respiratory organ (gill) (Fig. 12) 3.0 mm long, often reaching hind margin of thorax; consisting of a short, rather broad base, covered with minute spicules, and with one thick basal branch projecting posteriorly over thorax and dividing apically into two or more slender filaments, and with two similar, thick, closely appressed basal branches, one stouter than the other, which project anteriorly

← Figs. 12–21. *Simulium (H.) hieroglyphicum*. Figs. 12–15, pupa. 12, Respiratory organ (gill) (anterior branch to the left). 13, Cocoon. 14, Portion of frons showing integumental pattern. 15, Abdomen showing chaetotaxy on dorsal (d) and ventral (v) surfaces. Figs. 16–21, larva. 16, Inner distal and subapical margins of mandible showing dentation. 17, Antenna. 18, Anal sclerite. 19, Anal papillae. 20, Hypostomal cleft. 21, Hypostoma.

over head and apparently not dividing into finer filaments apically nor giving rise to other filaments along their dorsal surfaces; dorsal surface of main posterior branch giving rise to about 60–90 relatively short, slender, pale grayish white filaments, some of which are simple, and some dividing at varying distances from their bases into two or more apical filaments. Frons (Fig. 14) with a series of strong, rugosities giving rise to short, spurlike projections; without other granulations; antenna of both female and male reaching only about $\frac{1}{2}$ distance to hind margin of head; a single, short, fine seta present medial to base of each antenna. Dorsum of thorax with strong rugosities, some with short, spurlike projections; these rugosities arranged in a loose reticulate pattern, without other granules dorsally; two long, simple, dorsal trichomes present on each side of thorax. Chaetotaxy of each lateral half of tergites as follows (Fig. 15): tergite one with two fine setae and a closely associated lateral patch of minute spinules; tergite two with three fine setae, and a median patch of minute spinules; tergite three with three small hooklets, three fine setae, and a patch of minute spinules anterolateral to hooklets, and a similar but smaller patch just posterior to hooklets; tergites four and five each with four stout, anteriorly directed hooks near hind margin, 3–4 fine setae, and an anterolateral patch of minute spinules; tergites 6–8 without fine setae but with a small anterolateral patch of minute spinules; tergite nine bare, caudal spines absent. Chaetotaxy of each lateral half of sternites as follows: sternites 1–3 bare; sternites 4–5 each with an anterolateral patch of minute spinules; sternites 6–7 each with two anteriorly directed hooks, and sternite eight with one similar hook, all three of these sternites with a patch of minute spinules just anterior to hooks; sternite nine with an anterior patch of minute spinules across its width. Cocoon (Fig. 13) boot-shaped, densely woven, with floor extending anteriorly about $\frac{1}{2}$ length of flat bottom portion of cocoon; in lateral view, anterior collar of

cocoon relatively short, slanting anterodorsally, with one or two small festoons or windowlike openings near anterolateral margin, which, however, are easily broken off and lost.

Larva.—Length 13.0–13.5 mm. Body gradually expanding posteriorly; color grayish dorsally, lighter and more yellowish ventrally; intersegmental lines rather broad, slightly lighter than rest of abdomen dorsally. Head capsule brown, darker laterally and ventrally; head spots darker than rest of frontoclypeal apotome, posteromedian spot broad basally, strongly tapering distally, well separated from anteromedian spot, this paler and not as distinct; first anterolateral spot not discernible, second anterolateral spot large, distinct, well separated from first posterolateral spot, this smaller and less distinct; second posterolateral spot large but pale and diffuse; eye spots large. Antenna (Fig. 17) slightly longer than stalk of labral fan; proportions of segments (basal to apical) 1:2:0.68; dorsal half of basal two antennomeres yellowish brown, ventral half transparent, distal antennomere entirely yellowish brown. Labral fan with 52–59 (av. 55) primary rays. Hypostoma as in Fig. 21; median tooth short but longer than others; lateral teeth small, subequal in length but distal margin convex; lateral margins of hypostoma with 1–3 variable but small, weak serrations; 11–13 hypostomal setae along each margin and with 1–3 much smaller, more medial setae near hind margin. Hypostomal cleft (Fig. 20) moderately deep, extending about $\frac{2}{3}$ distance to base of hypostoma, a narrow inverted V-shape. Hypostomal bridge slightly but distinctly longer than hypostoma. Mandible (Fig. 16) with 3–5 apical teeth, 5–8 preapical teeth, and inner subapical ridge with one fine but prominent tooth. Maxillary palpus 2.5 times as long as width at base. Lateral plate of proleg short and broad, heavily sclerotized, extending about $\frac{1}{4}$ length of apical segment; circle of apical hooks in about 80 rows of about 20 hooks each. Rectal setulae minute; anal papillae (Fig. 19) complex, arranged in

three main groups of about 22-24-41 short, digitiform papillae. Anal sclerite (Fig. 18) heavily sclerotized, arms slender, narrowly joined; anterodorsal arms about $\frac{2}{3}$ as long as posteroventral arms, anterodorsal arms terminating in slightly enlarged, subquadrate to subrectangular, lightly sclerotized plates. Posterior circle of hooks consisting of 50-55 hooks in 500-550 rows.

Types.—Holotype, ♂ (reared with associated pupal pelt, all preserved in alcohol), stream (#34), upstream from bridge, Río Poasito, Cantón Poás, Provincia Alajuela, Costa Rica, November 4, 1986. A. Solano V. and W. González. The stream is located 23.5 km from Carrizal on the road to Poás Volcano.

Paratypes.—1 ♂ (mounted on 5 slides), same data except January 31, 1970; 1 ♀ (mounted on six slides) (reared with associated pupal pelt mounted on two slides), same data except July 18, 1986; 1 ♀ (mounted on five slides), 2 ♂♂ (one male mounted on four slides and one mounted on three slides) (all reared with associated pupal pelts each mounted on two slides), same data except August 8, 1986; 1 ♀ (reared) (pinned), 1 ♂ (pinned) and 2 ♂♂ (in alcohol), same data except August-September 1986; 1 pupa, same data except August 9, 1968; 19 pupae, same data except January 1, 1970; 10 pupae, same data except March 20, 1970; 5 pupae, same data except August-September 1986; 12 larvae, same data except January 31, 1970; 3 larvae, same data except March 20, 1970; 3 larvae, same data except September 5, 1986 (one larva mounted on six slides; two mounted on five slides each); 58 larvae, same data except August-September 1986.

Holotype deposited in the collection of the U.S. National Museum of Natural History, Washington, D.C. Paratypes are deposited in the U.S. National Museum of Natural History, and the entomology collection of the Department of Parasitology, University of Costa Rica.

Etymology.—The specific name is the singular, neuter form of the Latin adjective

hieroglyphicus, and refers to the hieroglyphic-like markings on the dorsum of the head capsule and thorax of the pupa.

Biological notes.—All available specimens of *Simulium* (*Hemicnetha*) *hieroglyphicum* came from the same stream (#34) of the type locality. The stream arises from nearby slopes, which are covered with abundant vegetation and large trees that shade the area, and then passes through pasture land at about 1940 m in elevation. The stream is about 3 m wide, 0.3 m in depth and has a moderate to fast cascading flow over large boulders and smaller stones. A small amount of trailing vegetation, mostly torch ginger (*Nicolaia elatior* (Jack) Horan), occurs along the stream banks. There is no emergent vegetation in this portion of the stream. The water is unpolluted and ranges in temperature from 13 to 14°C. Larvae and pupae were found on both rocks and trailing vegetation. Adults were neither attracted to nor taken biting humans.

Remarks.—There is not full agreement as to the subgeneric assignments of a number of species of black flies. This is especially true for the Neotropical species, and, in fact, Vulcano (1967) in her catalog of the black fly species of the Americas south of the United States, did not assign species to any subgenera. Based on larval characters and those of the male and female terminalia, as described by Stone (1963), we have selected for inclusion in the key to pupae presented below those species that seemed to us to belong to *Hemicnetha*; even so, there might be some eventual reassignments as the Neotropical species are more thoroughly studied and become better known in all their life history stages.

There currently are no keys that include all the adult and immature stages of all the described species of *Hemicnetha*. Adults of *S. hieroglyphicum* do not satisfactorily run to any species in the keys of Dalmat (1955) or Vargas and Díaz Nájera (1957). Even though they seem to be most similar to *S. smarti* Vargas they differ in many more characters than there are similarities. Fe-

males of *S. hieroglyphicum* can be distinguished from those of all other known species by the Sc being setose ventrally except for about apical 1/5 which is bare, these setae placed in a single row except at the extreme base (four to five setae long) in which they are placed in a double row; anterior marginal area of scutum with numerous clusters of 2-3 golden yellow scale-like setae; the three dark, slender vittae that are visible in posterior view; and by the shape and form of the various genital structures (see Figs. 9-11). The males can be distinguished from all other known males of this group by the following combination of characters: Sc bare except for about 12 setae at extreme base; scutum without distinct dark vittae, but clothed with numerous groups of golden yellow, scalelike setae; broad hind basitarsus; and the distinctive form of the genital structures (see Figs. 7-8).

The respiratory organ, or gill, of the pupa of *S. hieroglyphicum* is distinctly different from those of all other known species as demonstrated by the following key. Two species, viz *muiscorum* Bueno, Moncada, and Muñoz de Hoyos, and *keenani* Field, are included in the key on the basis of published descriptions as we do not have material of these species to check for distinguishing characters. Although we have specimens of *pulverulentum* Knab we lack material of *S. guerrense* Vargas and Díaz Nájera and so have followed the key of Vargas and Díaz Nájera (1957) to separate the pupae of these two species. Consequently, the key is not complete but it should be useful for separating the pupae of the majority of the species included. In the literature there are only a few other keys to pupae that contain two or more of the species that we include in *Hemicnetha*, and these are included under varying names and in varying combinations of species. None of these keys include all the species that are in the key given below. The pupa of *S. (H.) dehnei* Field, from Panama, is not known

and so does not appear in the key. We are unable, at this time, to prepare a reliable key to the other stages of the species of *Hemicnetha* because of the lack of adequate material.

KEY TO NEW WORLD SPECIES
SIMULIUM (HEMICNETHA)
PUPAE

- 1. Respiratory organ (gill) with six filaments 2
- Respiratory organ with eight or more filaments 4
- 2. Two of the six filaments much shorter than the other four. Granulations on dorsum of thorax with spinules (Venezuela; fig. 30A, B, J, P in Ramírez-Pérez 1983)
..... *oviedo* Ramírez-Pérez
- All filaments subequal in length. Granulations on dorsum of thorax disk- or buttonlike and without spinules 3
- 3. Cocoon shorter and higher than in following species, anterolateral margin of cocoon nearly straight and set at almost a right-angle to anteroventral surface of collar (Brazil; figs. 23-25 in Pinto 1932)
..... *brachycladum* Lutz and Pinto
- Cocoon longer and lower than in above species, anterolateral margin of cocoon sloping and concave, anteroventral portion of cocoon projecting liplike (Venezuela; fig. 42D, E, K in Ramírez-Pérez 1983) *nyasi* Ramírez-Pérez
- 4. Respiratory organ with eight filaments 5
- Respiratory organ with ten or more filaments 9
- 5. Cocoon boot-shaped, anterodorsal margin with well-developed festoons, these sometimes broken but traces of them usually remain 6
- Cocoon boot-shaped but anterodorsal margin simple, or with poorly-defined festoons 9
- 6. Frons almost totally covered by small spinules; thorax with small spinules ventral to base of respiratory organ. Caudal spines present but small (Colombia, Guyana, Brazil, Argentina; figs. 33-41 in Vulcano 1958)
..... *rubrithorax* Lutz
- Frons smooth, with, at most, a few granulations but without spinules; thorax without spinules. Caudal spines absent 7
- 7. Filaments arising from stem in two distinct groups of four filaments each (U.S.A., Mexico, Guatemala, Panama; figs. 7, 9 in Stone 1948; and 263, 270 in Vargas and Díaz Nájera 1957) *virgatum* Coquillett
- Filaments all arising at about the same level from a common stem 8

- 8. Filaments slender, about 0.12 mm in width at base; thorax less densely granulose than in following species (Venezuela; figs. 1-4 in Ramirez-Pérez and Vulcano 1973; and IOB, O, P in Ramirez-Pérez 1983) *conviti* Ramirez-Pérez and Vulcano
- Filaments broader, about 0.60 mm in width at base; thorax more densely granulose than in above species (Mexico, Guatemala, Costa Rica, Panama, Venezuela; figs. 235, 237 in Vargas and Díaz Nájera 1957) ... *paynei* Vargas
- 9. Anterodorsal margin of cocoon with poorly developed festoons. Thorax strongly rugose in a somewhat reticulate pattern. All filaments petiolate, branching some distance from base (Mexico; figs. 181, 185, 186 in Vargas and Díaz Nájera 1957) *bricenoi* Vargas, Martínez Palacios, and Díaz Nájera
- Anterodorsal margin of cocoon without festoons. Thorax granulose but without reticulate rugosities. All filaments branching close together at or near the base (Mexico; figs. 198, 204 in Vargas and Díaz Nájera 1957) *freemani* Vargas and Díaz Nájera
- 10. Respiratory organ with ten filaments 11
- Respiratory organ with 12 or more filaments 14
- 11. Thorax densely covered with black spinules (Mexico; figs. 213, 216, 221 in Vargas and Díaz Nájera 1957) *himmani* Vargas, Martínez Palacios, and Díaz Nájera
- Thorax may be granulose but without spinules 12
- 12. Anterior collar of cocoon raised well above level of dorsum of pupal thorax; anterior face of collar almost vertical, its dorsolateral margins curving posteriorly downward in undulating fashion (Mexico, Guatemala; figs. 273, 276 in Vargas and Díaz Nájera 1957) *yepocapense* Dalmat
- Anterior collar of cocoon only raised slightly above level of dorsum of pupal thorax; anterior face of collar distinctly oblique, its dorsolateral margins not undulating downward posteriorly, but simple and at least slightly directed anteroventrally 13
- 13. Anterodorsal margin of cocoon obliquely slanted anteroventrally. Respiratory organ with filaments somewhat longer and more isolated from each other (Mexico; figs. 210, 211 in Vargas and Díaz Nájera 1957) *guerrense* Vargas and Díaz Nájera
- Anterodorsal margin of cocoon more horizontal, only slightly slanting anteroventrally. Respiratory organ with filaments somewhat shorter and more closely clumped [no characters are known that reliably separate pupae of this species from pupae of the above species] (Mexico, Guatemala, Belize, El Salvador, Panama, Venezuela; figs. 243, 246 in Vargas and Díaz Nájera 1957) ... *pulverulentum* Knab
- 14. Respiratory organ with 12 filaments 15
- Respiratory organ with 16 or more filaments 17
- 15. Anteroventral margin (lip) of cocoon deeply notched medially so that lateral portions are produced anteriorly as two subtriangular or spatulate processes (Mexico, Guatemala, Panama, Trinidad and Tobago, Venezuela, Colombia, Bolivia; figs. 226, 230 in Vargas and Díaz Nájera 1957) ... *mexicanum* Bellardi
- Anteroventral margin (lip) of cocoon simple, without a medial notch and without subtriangular or spatulate processes 16
- 16. Respiratory organ with relatively short filaments branching antlerlike; filaments without minute tubercles. Thorax without trichomes. Abdomen with two strong caudal spines (Argentina; fig. 6A-J in Wygodzinsky 1949) *lahillei* Paterson and Shannon
- Respiratory organ with relatively short filaments but these not branching antlerlike; filaments covered by minute tubercles. Thorax with branched trichomes. Abdomen without caudal spines (Colombia; figs. 22-26 in Bueno et al. 1979) *muiscorum* Bueno, Moncada, and Muñoz de Hoyos
- 17. Respiratory organ with 15-16 filaments 18
- Respiratory organ with 18 or more filaments 20
- 18. Anterior collar of cocoon raised well above level of dorsum of pupal thorax; dorsolateral margins of opening of cocoon curving posteriorly downward in undulating fashion. Respiratory organ with 16 filaments (Mexico, Guatemala; figs. 189, 195 in Vargas and Díaz Nájera 1957) *earlei* Vargas, Martínez Palacios, and Díaz Nájera
- Anterior collar of cocoon only raised slightly above dorsum of pupal thorax; dorsolateral margins of opening of cocoon not curving posteriorly downward in undulating fashion. Respiratory organ with 15-16 filaments 19
- 19. Respiratory organ usually with 15 filaments, 14 in pairs and 1 single filament. Dorsum of thorax smooth. Anterior collar of cocoon short, raised slightly above dorsum of pupal thorax, dorsolateral margins of opening of cocoon straight or slightly concave; (U.S.A., Mexico; figs. 8, 10 in Stone 1948; figs. 255, 261 in Vargas and Díaz Nájera 1957) ... *solaris* Stone
- Respiratory organ with 16 filaments variously

- branching near base, some filaments branching in groups of three, some in pairs, and at least three singles. Anterior collar of cocoon longer (Panama; fig. 8 in Field 1969)
- *keenani* Field
20. Respiratory organ with 18 filaments. Head and thorax without hieroglyphic-like rugosities (Mexico, Guatemala; figs. 252, 254 in Vargas and Díaz Nájera 1957) . . . *smartii* Vargas
- Respiratory organ with two main branches, a posterior branch giving rise to 60–90 short, white filaments, and an anterior branch that divides into two filaments apically. Head and thorax with hieroglyphic-like rugosities (Costa Rica, fig. 11 herein)
- *hieroglyphicum* Peterson, Vargas, and Ramírez-Pérez

ACKNOWLEDGMENTS

We thank R. Echeverri, W. González, and the Centro de Investigación y Diagnóstico en Parasitología, Universidad de Costa Rica, for field and technical support in this investigation. Financial and logistic support was provided for our studies by the Vicerrectoría de Investigación, Universidad de Costa Rica; and the International Committee of Migrations (CIM) provided financial support to J. Ramírez-Pérez for travel to Costa Rica. We are grateful to P. Malikul, laboratory technician, Systematic Entomology Laboratory, for help in the preparation of the plates that accompany this paper. We thank J. W. Amrine, Jr., Department of Entomology, West Virginia University, Morgantown, W.V., W. N. Mathis, Department of Entomology, Smithsonian Institution, Washington, D.C., and D. C. Ferguson, A. L. Norrbom and F. C. Thompson, Systematic Entomology Laboratory, ARS, USDA, for reading and commenting on the manuscript.

LITERATURE CITED

- Barreto, P. 1969. The species of black flies found in Colombia (Diptera: Simuliidae). *J. N.Y. Entomol. Soc.* 77: 31–35.
- Bueno, M. L., L. I. Moncada, and P. Muñoz de Hoyos.

1979. Simuliidae (Insecta: Diptera) de Colombia. I. Nueva especie de *Simulium* (*Hemicnetha*). *Caldasia* 12: 581–594.
- Dalmat, H. T. 1955. The black flies (Diptera, Simuliidae) of Guatemala and their role as vectors of onchocerciasis. *Smithsonian Misc. Colls.* 125: 1–425, 44 Pls.
- Field, G. 1969. Studies of black flies of Panama. III. Two new species of *Simulium* of the subgenus *Hemicnetha*. *Ann. Entomol. Soc. Am.* 62: 157–163.
- Pinto, C. 1932. Simuliidae da America Central e do Sul (Diptera). 7^a Reun. Soc. Argent. Patol. Reg. Norte 60: 661–763, 1931.
- Ramírez-Pérez, J. 1971. Distribución geográfica y revisión taxonómica de los simulidos (Diptera: Nematocera) de Venezuela con descripción de diez especies nuevas. *Acta Biol. Venez.* 7: 271–371.
- . 1983. “Los jejenes de Venezuela.” Simposio de Oncocercosis Americana, Caicet, Puerto Ayacucho, 15–17 Octubre 1983; 156 pp.
- Ramírez-Pérez, J., B. V. Peterson, and M. Vargas V. 1988. *Mayacnephia salasi* (Diptera: Simuliidae), a new black fly species from Costa Rica. *Proc. Entomol. Soc. Wash.* 90: 66–75.
- Ramírez-Pérez, J. and M. A. Vulcano. 1973. Descripción y redescrpciones de algunos simulidos de Venezuela (Diptera: Simuliidae). *Arch. Venez. Med. Trop. Parasitol. Med.* 5: 375–399.
- Stone, A. 1948. *Simulium virgatum* Coquillett and a new related species (Diptera: Simuliidae). *Jour. Wash. Acad. Sci.* 38: 399–404.
- . 1963. An annotated list of genus-group names in the Family Simuliidae (Diptera). *Agr. Res. Serv., U.S. Dept. Agr., Tech. Bull.* 1284: 1–28.
- Vargas, L. and A. Díaz Nájera. 1951. Notas sobre sistemática y morfología de simulidos. *Rev. Soc. Mex. Hist. Nat.* 12: 123–172, 17 Pls.
- . 1957. Simulidos Mexicanos. *Rev. Inst. Salub. Enfer. Trop.* 17: 143–399.
- Vulcano, M. A. 1958. Redescrção do *Simulium rubrithorax* Lutz, 1909, e descrição do alotipo ♂ (Diptera, Simuliidae). *Papéis Avulsos, Dept. Zool., Sect. Agric., São Paulo* 13: 227–240.
- . 1967. 16 Family Simuliidae, pp. 1–44. *In* N. Papavero, ed., *A Catalogue of the Diptera of the Americas South of the United States*. Dept. Zool., Sect. Agric., São Paulo.
- Wygodzinsky, P. 1949. Contribuciones al conocimiento de los Simuliidae Argentinos. I. Introducción. Redescrpción de *Simulium lahillei* Paterson y Shannon, 1927 (Diptera). *Anal. Inst. Med. Reg., Univ. Nacional de Tucumán* 2: 303–319.